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XVIII.—*On the Classification of the Orders of Orthoptera and Neuroptera.* By A. S. PACKARD, Jun.*

IN the forthcoming third report of the U. S. Entomological Commission we have endeavoured to ascertain the position of the Orthoptera in reference to allied ametabolous insects. The following pages are extracted from the chapter, with some omissions.

We have examined the fundamental characters of the head, thorax, and abdomen (points neglected by most systematic writers), not spending much time on the peripheral, *i. e.* the superficial, adaptive characters of the mouth-parts, wings, and legs, which have been elaborated by systematic entomologists, believing that by this method perhaps more thorough and better-grounded views might result. The outcome has been to lead us to separate the Neuroptera, as defined further on, from the Pseudoneuroptera, and to regard these two groups, with the Orthoptera and Dermaptera, as four orders of a category which may be regarded as a superorder, for which the name Phyloptera is proposed, as these four orders are probably closely allied to, if not in some cases identical with, the stem or ancestral groups from which probably all the higher

* From a separate impression from the 'American Naturalist' for August 1883, communicated by the Author.

orders (the Hemiptera, Coleoptera, Diptera, Lepidoptera, and Hymenoptera) have originated.

We will first briefly summarize the characters, as we understand them, of the Phyloptera as a whole; then the distinguishing marks of the four orders.

Superorder PHYLOPTERA*.

The mouth-parts are free, adapted invariably for biting, the mandibles being toothed and adapted for chewing; the first maxillæ separate, with three divisions, the outer bearing usually five-jointed palpi; the second maxillæ united to form a labium divided into a submentum, mentum, and ligula, the latter varying much, being either cleft (Pseudoneuroptera) or entire (Neuroptera), and bearing usually a three-jointed palpus. This is the primitive elementary condition of the mouth-parts, and such as obtains in Coleopterous larvæ. The head is notable from the great development of the epicranium. The clypeus is often divided into two portions, a posterior (post-clypeus) and anterior (anteclypeus); in the other and higher orders the clypeus is entire.

The prothorax is usually very large and square; but in a few families, as the Phryganeidæ, Panorpidæ, Psocidæ, Libellulidæ, and Ephemericidæ, it is small and collar-like. There is a marked equality in size and form of the meso- and metathorax; in most Orthoptera and some Pseudoneuroptera and Neuroptera the metathorax is often even larger than the mesothorax; in this respect the Phyloptera differ from any of the higher Hexapoda. In both of the two hinder segments of the thorax the four tergal sclerites, viz. the præscutum, scutum, scutellum, and postscutellum, are each well developed, and more equably so than in any other order. The scutum is deeply excavated in front to receive the often large subtriangular or cordate præscutum; and in some genera the scutum is, so to speak, cleft in two by the meeting of the præscutum and scutellum in the median line. The flanks of the thorax or pleurites, are often very large, and the episternum and epimerum are broad, oblong, or squarish; and these sclerites are sometimes subdivided into an upper and a lower division (supra- and infra-epimerum or episternum). The sternum is often large, flat, and broad; it is sometimes divided into a sternum and præsternum.

The wings are usually net-veined, often with numerous longitudinal veins, the branches of the subcostal, median, and submedian veins being either very long and parallel with the

* From *φύλλον*, gens, nation; *πτερόν*, wing.

longitudinal axis of the wing, or numerous and small (especially in the hind wings of Orthoptera).

The hind wings are often (Orthoptera and Odonata) broader and larger than the anterior pair, the metathorax in such cases being a little larger than the mesothorax.

The abdomen has in this group, including representatives of the Neuroptera, Orthoptera, Dermaptera, and Pseudoneuroptera, besides a tenth nearly complete segment, the rudiments of an eleventh uromere, represented by a tergite forming the supraanal triangular plate. Well-developed jointed cercopoda occur in the Orthoptera and Pseudoneuroptera, while the forceps of Forficula (Dermaptera) are undoubtedly modified cercopoda. An ovipositor occurs in the Neuroptera (Panorpidae) and Orthoptera.

The metamorphosis is incomplete in all the orders of Phyloptera except the more recent and higher order, *i. e.* the Neuroptera (in Erichson's sense), in which the transformations are complete, the pupa being quiescent and wholly unlike the larva.

The relative standing of the four orders of Phyloptera is shown in the table or genealogical tree of the winged insects on page 154.

The sequence of the orders, such as we are compelled to adopt in writing or speaking of them, is difficult to decide upon. Beginning with what on the whole may be regarded as the lowest order, we might first take up the Dermaptera, which are, in most respects, the most generalized forms, and stand nearest to the Thysanura (*Japyx*).

The following is the succession of orders, placing the lowest uppermost:—

Dermaptera, Burm.

Orthoptera, Linn.

Pseudoneuroptera, Erichson.

Neuroptera, Linn., as restricted by Erichson.

Before discussing the relative standing of these orders, we will briefly indicate the more salient and generally applicable differential characters, especially what we regard as the more fundamental ones, but slightly touching upon the mouth-parts and wings, these being peripheral and more adaptive characters and liable to greatest variation, and being of less value in characterizing the orders of Phyloptera.

Order 1. DERMATOPTERA.

Forficula presents so many features separating it from the

Orthoptera, and is so composite a form, that it should be regarded as the type of a distinct order, in which it was originally placed by Leach, Kirby, Burmeister, and Westwood. Its composite nature is seen both in the elytra and the hind wings, which anticipate the Coleopterous type of wings. On the other hand, the larvæ resemble *Japyx*, the Thysanuran, with its anal forceps; and in most respects *Forficula* is the lowest, most decided stem form of the Phylloptera.

The Dermaptera are characterized by the flatness of the body and the large terminal forceps. The head is flat, horizontal in position, while the presence of the V-shaped epicranial suture is a sign of inferiority, as it is characteristic of Thysanura and Platyppteran larvæ as well as of Coleopterous larvæ. The remarkable thoracic structure, which is described further on, as well as the curious overlapping of the abdominal tergites, forbid our uniting the Dermaptera with the Orthoptera. The small short elytra and the very large, rounded, longitudinally and once crossfolded hind wings, which remind us rather of the Coleoptera than Orthoptera, are also important diagnostic features. Finally the metamorphosis of the Dermaptera is even less complete than that of the Orthoptera.

The ligula is bifid, being divided into a pair of two-jointed paraglossæ. The labium is thus similar to that of the Orthoptera, though scarcely more like them than like *Termes*.

Order 2. ORTHOPTERA.

The head is more or less vertical in position; the front is very large, broad, and long, the epicranial region very large and often hypertrophied. The clypeus is large and subdivided as in Pseudoneuroptera. In the Orthoptera, as a rule, the deeply-cleft ligula is indistinctly four-lobed, the outer pair of paraglossæ very well developed, while the inner pair is minute or undeveloped, as in the Acrydii, especially *Caloptenus*; but in the Locustariæ the ligula is four-lobed, and in the Gryllidæ decidedly so. In the Mantidæ and Blattariæ the ligula is plainly four-lobed, nearly as much so as in the Termitidæ. In the Phasmidæ the ligula is intermediate in form between the Mantidæ and Locustariæ.

The prothorax is usually remarkably large, particularly the notum. The meso- and metanotum exactly repeat each other, and the metanotum is usually (Acrydii and Locustariæ) longer and larger than the mesonotum, the hind wings being almost uniformly much larger than the anterior pair. The pleurites are very large and square as well as high, the episterna and epimera being large and oblong and equally developed. The

sternites are very large and broad. The coxæ are sometimes (*Blatta*) very large; the hind legs in the Acrydii are much larger than the anterior pairs. The fore wings are narrower than the hinder pair, and show a slight tendency to become subelytriform; on the other hand, the hind wings are very large and broad, distinctly net-veined, with numerous longitudinal veins, and they fold up longitudinally.

The abdomen has eleven uromeres, the eleventh forming a triangular tergite. The cercopoda are often (*Blatta*, *Mantis*, &c.) multiarticulate and well developed, while the ovipositor is often large and perfect. The metamorphosis is more incomplete than in the Pseudoneuroptera.

With the exclusion of the Forficulariæ, the Orthoptera, as here restricted, are a tolerably well-circumscribed group; and though there are great structural differences between the families, yet the connexion or sequence of the families from the Blattariæ through the Phasmidæ and Mantidæ and Acrydii to the Locustariæ, and finally the highest family, the Gryllidæ, is one which can be distinctly perceived. There is no occasion for a subdivision of the order into groups higher than families, as the Blattariæ are but a family removed from the Mantidæ.

Order 3. PSEUDONEUROPTERA, Erichson.

It is difficult, if not impossible, to satisfactorily characterize by a sharp-cut definition this very elastic order. As regards the thorax, there is no uniformity in the structure that we have been able to discover, nor is there in the structure of the wings, nor more than a general resemblance in the mouth-parts.

The definition of the Pseudoneuroptera in Hagen's 'Synopsis of the Neuroptera of North America,' as given in the analytical table, which is stated in a footnote to have been prepared at the request of the Smithsonian Institution by Baron Osten Sacken, gives no fundamental characters based on a study of the trunk. Those mentioned are what we have called peripheral characters, *i. e.* those drawn from the mouth-parts, wings, and appendages. So far as we know, no satisfactory definition of the Pseudoneuroptera has ever been given. In Hagen's 'Synopsis,' among the other superficial characters given are these:—"Lower lip mostly cleft;" "antennæ either subulate and thin, the tarsi three- to five-articulate, or setiform or filiform, in which case the tarsi are two- to four-articulate." These characters, though superficial, are the most important yet presented, perhaps (disregarding the

metamorphosis), for separating the Pseudoneuroptera from the genuine Neuroptera. But the cleft labium is also to be found in Orthoptera; and among the Orthoptera, which usually have five-jointed tarsi, the Mantidæ have four tarsal joints. The Perlidæ, Odonata, and Ephemerina have been by Gerstäcker (Peters and Carus's 'Zoologie') associated with the Orthoptera under the name *Orthoptera amphibiotica*; but such an alliance does not seem to us to be entirely a natural or convenient one; it is simply transferring a mass of heterogeneous forms to what, as now limited, is a natural and well circumscribed category; and yet we confess that it is difficult to give diagnostic adult characters separating the Pseudoneuroptera from the Orthoptera, though the general facies of the Orthoptera is quite unlike that of the Pseudoneuroptera.

In the Pseudoneuroptera, beginning with the more generalized forms, the Perlidæ and Termitidæ, the labium (second maxillæ) is deeply cleft, the cleft not, however, in these or any other insects, extending to the mentum, or even clear through the palpiger. Each lobe is also cleft, so that the ligula is really four-lobed; the outer lobes are called by Gerstäcker* the "lamina externa," and the inner the "lamina interna." These finger-shaped non-articulated fleshy lobes appear to be homologous with, or at least suggest, the outer pair of paraglossæ of the Coleoptera and Hymenoptera. In the Perlidæ the four lobes of the ligula are well developed, and the lobes of the inner pair are broader than the outer. In the Termitidæ the lobes are well developed, but the inner pair of lobes is either one half or not quite so wide as the outer paraglossæ; the palpiger is cleft. In the Embidæ, according to Savigny's figures, the ligula is four-lobed, but the inner pair are narrow and rudimentary.

In the Odonata, according to Gerstäcker's excellent drawings, the ligula varies much. In *Gomphus* it is entire; in some of the higher Libellulinæ only two-lobed; but in *Æschna* it is four-lobed, the outer lobe slender but separate from the palpus. In *Calopteryx* the ligula is widely cleft, the two inner lobes are wide apart, while the outer pair are consolidated with the labial palpi. Owing to the specialized nature of the labial palpi, the mouth-parts of the Odonata are sufficiently *sui generis* and distinctive to prevent their being placed among the Orthoptera, even if the thorax were not so dissimilar. In the aborted labium and other mouth-parts of the Ephemerina we also have strongly-marked characteristics

* "Zur Morphologie der *Orthoptera amphibiotica*," Aus der Festschrift zur Gesellsch. naturforsch. Freunde, 1873.

forbidding their being placed in the Orthoptera; were it not for the strong resemblance of the Termitidæ to the Orthoptera (Blattariæ), probably no one would have thought of carrying the Pseudoneuroptera over into the Orthoptera.

The relative proportion of the head and sclerites varies greatly; no general rule can be laid down as to the relative proportions of the epicranium and of the clypeus or of the gular region.

On this account I had at one time decided to split the group into two, and to restrict Erichson's Pseudoneuroptera to the Platyptera*, and to adopt Latreille's term Subulicornia for the Odonata and Ephemerina (Subulicornes of Latreille). It may, however, be best for the sake of clearness to retain Erichson's order Pseudoneuroptera as he indicated it, and to dismember it into what may be regarded, provisionally at least, as three suborders:—

1. *Platyptera* (Termitidæ, Embidæ, Psocidæ, and Perlidæ = Corrodentia and *Orthoptera amphibiotica* in part).
2. *Odonata* (Libellulidæ).
3. *Ephemerina* (Ephemericidæ).

It is comparatively easy to give well-grounded differential characters for these three suborders. They are so distinct that they may perhaps hereafter be regarded as entitled to the rank of orders, or the Pseudoneuroptera may be dismembered into the Pseudoneuroptera and Subulicornia (Odonata and Ephemerina).

1. *Platyptera*.—The body is flattened; the head horizontal. The pronotum is large, broad, and square. The meso- and metanotum are remarkable on account of the imperfect differentiation of the scutum and scutellum; the latter is indefinite in outline, but very large. The flanks (pleurites) are, when long, oblique or are short. The sternites are usually very large and broad. There are often eleven uromeres.

2. *Odonata*.—While the Odonata and Ephemerina are somewhat alike as regards the form and venation of the fore wings, in their mouth-parts and thorax they are entirely unlike. The Odonata are remarkable for the great dorsal (tergal) development of the mesepisterna and the enormous development of the meso- and metapleurites in general, while

* This name (*πλατύς*, flat, *πτερόν*, wing) is in allusion to the wings, which the majority (the Psocidæ folding their wings rather roof-like) fold flat on the back. The Isoptera of Brullé comprise the Termitidæ.

the notum of meso- and metathorax, though of the same type as in the Orthoptera, is minute in size. The prothorax is very small, both dorsally and on the sides forming a collar.

The wings are as markedly net-veined as in the Orthoptera, though the hinder pair are not folded longitudinally as in that order. The Odonata literally live on the wing, and thus the shape of the sclerites of the notum of the wing-bearing segments approaches that of the Orthoptera, although the prothorax is remarkably small compared with that of the Orthoptera, and forbids their union with this order, as was done by Gerstäcker and other German entomologists. The head of the Odonata is remarkable for the enormous size of the eyes and the consequent great reduction in size of the epicranium as compared with the large epicranium of the Orthoptera. The mouth-parts are like those of the Orthoptera, except that the second maxillæ form a remarkable mask-like labium. The abdomen is very long, slender, and cylindrical; there are eleven uromeres, the eleventh being well represented, while the cercopoda are not jointed, but in the form of claspers.

3. *Ephemerina*.—In the small epicranium and the large male eyes the Ephemerina resemble the Odonata, though the rudimentary mouth-parts are in plan entirely unlike theirs. So also the prothorax is small and annular; but the subspherical concentrated thorax is remarkable for the large mesothorax and the small metathorax. Hence the hind wings are small and sometimes obsolete. The long slender abdomen has ten uromeres, and bears, besides the two long filamental multiarticulate cercopoda, a third median one.

The larvæ of the lower Odonata and of the Ephemeridæ closely approach in form those of the Perlidæ, showing that the three suborders here mentioned probably had a common ancestry, which can be theoretically traced to a form not remote from *Campodea*. By reason of the general resemblance of the larval forms of these three suborders it would be unadvisable to separate the Odonata and Ephemerina from the Platyptera, although when we consider the adult forms alone there would appear to be some grounds for such a division.

Order 4. NEUROPTERA.

The head is horizontal and somewhat flattened, except in the Trichoptera and Panorpidæ, where it is subspherical and vertical. The body shows a tendency to be round or cylindrical, the thorax being more or less spherical; but there is

great diversity in form from the Sialidæ to the Trichoptera. The mouth-parts are free, and the mandibles well developed, except in the Trichoptera, where the mandibles are nearly obsolete in form and functionless, thus suggesting or anticipating the Lepidoptera.

In the Neuroptera the ligula is entirely unlike that of any of the foregoing and lower groups. It is entire, forming a broad, flat, large rounded lobe; it is largest in *Myrmeleon*, *Ascalaphus*, and *Mantispa*, but smaller in *Corydalidæ*, where it is also narrower and indented on the front edge.

In *Panorpa* the ligula is minute, rudimentary; in the Trichoptera it is also minute and rudimentary.

The prothorax is usually (Planipennia) large, broad, and square, but is ring- or collar-like in the Trichoptera, being short and small, much as in Lepidoptera. Except in the Trichoptera, the meso- and metanotum are characterized by the large cordate præscutum; and in the Hemerobina the metascutum is partially or (in *Ascalaphus*) wholly cleft, the præscutum and scutellum meeting on the median line of the thorax.

In the Hemerobina and Sialidæ the metathorax is as large or nearly as large as the mesothorax, and the hind wings are as large as the anterior pair. The wings are not net-veined, the type of venation being entirely unlike that of the Orthoptera and Pseudoneureptera. The costal space is wide and well marked, and the transverse veinlets are few and far apart compared with the two orders just mentioned.

The abdomen is cylindrical; and there are nine or ten uromeres. The ovipositor is only developed in *Rhaphidia*, while the cercopoda are not developed. The metamorphosis is complete, as in the Lepidoptera &c., the pupa being entirely unlike the larva, and quiescent, often protected by a cocoon or case. The order may be divided into two suborders:—

1. *Planipennia* (Sialidæ, Hemerobiidæ, Panorpidæ).
2. *Trichoptera* (Phryganeidæ).

The following tabular view will in a degree express our views as to the classification of the orders of the hexapodous or winged insects:—

Superorders.	Orders.	Suborders.
Euglossata *	{ Hymenoptera. Lepidoptera. Diptera	{ Diptera (genuina). Aphaniptera. Pupipara.
Elytrophora † . .	Coleoptera	{ Coleoptera (genuina). Strepsiptera.
Eurhynchota ‡ . .	Hemiptera	{ Homoptera. Heteroptera. Physapoda. Mallophaga.
Phyloptera	{ Neuroptera Pseudoneuroptera . . Orthoptera Dermatoptera.	{ Trichoptera. Planipennia.
		{ Odonata. Ephemerina. Platyptera.
Synaptera §	Thysanura	{ Cinura. Symphyla. Collembola.

XIX.—On Ure's "Millepore," *Tabulipora* (Cellepora) *Urii*,
Flem. By JOHN YOUNG, F.G.S.

To the Editors of the 'Annals and Magazine of Natural
History.'

GENTLEMEN,—In vol. xiii. (4th series) of the 'Annals'
(for 1874) there is a short paper by R. Etheridge, Jun., en-
titled "Observations on *Chaetetes tumidus*, Phill.," in which,

* We propose the name Euglossata for the highest insects, comprising
those orders which, besides having the mouth-parts (either the first or
second maxillæ or both) modified so as to sip, suck, or lap up liquid food,
also have the body cylindrical and the thorax more or less spherical and
concentrated.

† This term is proposed for the Coleoptera alone.

‡ This term is proposed for the Hemiptera, in all of which, except the
Mallophaga and Physapoda (*Thrips*), the mouth-parts are united to form
a sucking-beak.

§ This term is proposed for the Thysanuran apterous Hexapods, which
are perhaps nearly the morphological equivalents of either of the three
other superorders.